UNIVERSITI PUTRA MALAYSIA

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By

MUHD AZLAN BIN ABD GHANI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Master of Science

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November 2010

Chair : Associate Professor Yahya bin Awang, PhD

Faculty : Institute of Tropical Agriculture

Dragon fruit (*Hylocereus polyrhizus*) is a non-climacteric fruit, normally harvested at a full maturity stage (index five) in order to get the best marketing quality. Harvesting at such stage shortens storage life and renders the fruit more susceptible to disease infection. This study was designed to test the possible beneficial effects of calcium (Ca) on fruit quality as well as on the occurrence of anthracnose (caused by *Collectotrichum gloeosporioides*) and brown rot (caused by *Monilinia fructicola*). Initially, the pathogenicity of four types of identified fungi, i.e. *C. gloeosporioides*, *M. fructicola*, *Fusarium* sp. and *Curvularia* sp. on red dragon fruit was studied. Fully matured fruits (index five) were wounded and inoculated with spore of respective fungi at 10^8 spore·mL^{-1}. Two days after incubation, 100% of the inoculated fruits were infected by three species of the fungi species tested except those inoculated with *Curvularia* sp. as

well as control fruit. Further experimentation was conducted to study the effect of diseases on fruit quality parameters, involving inoculation of two spore concentrations of *C. gloeosporioides* and *M. fructicola* (10^4 and 10^6 spores·mL^{-1}). All fruits revealed 100% of infection except in fruit inoculated with 10^4 spores·mL^{-1} *M. fructicola* and control. The disease severity also was dependent on spore concentrations. At higher spore concentration, brown rot disease caused by *M. fructicola* was more severe compared to anthracnose (caused by *C. gloeosporioides*), with their respective lesion size at 8.4 and 5.8 cm^2 three days after incubation (DAI). Diseased fruits were softer, low in soluble solids contents (SSC), titratable acidity (TA) but higher in pH. Prolonging the incubation period to five days increased the size of disease lesions as well as reduced fruit quality. The disease lesion on fruits inoculated with *C. gloeosporioides* increased seven times from 9.6 at three DAI to 63.0 cm^2 at five DAI. Meanwhile, the disease lesion increased nine times from 10.1 to 91.7 cm^2 for *M. fructicola*. These results show serious damage could arise from the anthracnose and brown rot diseases. Subsequently, the effect of preharvest calcium application on disease occurrence and fruit quality was studied by spraying calcium chloride ($CaCl_2$) solution directly on the fruits at five concentrations (0, 1.0, 2.0, 3.0 and 4.0 g·L^{-1}), at four weekly intervals. Results showed that the severity of anthracnose and brown rot was reduced with increasing Ca concentration. The size of lesions on fruits inoculated with *C. gloeosporioides* and *M. fructicola* declined up to 85 % and 91 % as the Ca concentration increased from 0 to 4 g·L^{-1}, respectively. Disease severity was negatively correlated to Ca content in fruit peel (r = - 0.91). Ca application promoted fruit firmness. Ca application at 4 g·L^{-1} brought firmness of infected fruit to a comparable value to

uninfected fruit treated at the same level of Ca. There was no effect of Ca application on pH, SSC and TA of uninfected fruit. However Ca application at higher concentration retained such quality attributes in infected fruit. Similar results were also observed in fruit treated with postharvest dipping at concentrations of Ca; 0, 1.0, 2.0, 3.0 and 4.0 $g \cdot L^{-1}$. Disease severity of fruits inoculated with *C. gloeosporioides* and *M. fructicola* was reduced up to 70 % and 65 % as the Ca concentration increased from 0 to 4 $g \cdot L^{-1}$, respectively. Fruit firmness was increased with increasing Ca concentration either in uninfected or infected fruit. The effect of disease on pH, SSC and TA of fruit was mitigated by Ca application. For the uninfected fruit, Ca dipping had no effect on such quality attributes. Pre- or postharvest Ca application was also successful in elevating fruit Ca content without affecting the uptake of nitrogen (N), phosphorous (P), potassium (K) and magnesium (Mg). In conclusion, Ca application as preharvest spraying or postharvest dipping was successful in reducing disease severity and mitigating the effect of diseases on quality of fruit as well as elevating the fruit Ca content. These findings seemed promising on the use of $CaCl_2$ for shelflife extension and storability of dragon fruits. $CaCl_2$ application could be used as part of the management strategy in reducing anthracnose and brown rot diseases in red flesh dragon fruits.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
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RAWATAN KALSIUM MELAWAN JANGKITAN ANTRAKNOS DAN REPUT PERANG PADA BUAH MATA NAGA [*Hylocereus polyrhizus* (F.A.C. Weber) Britton & Rose]

Oleh

MUHD AZLAN BIN ABD GHANI

November 2010

Pengerusi : Profesor Madya Yahya bin Awang, PhD

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Buah mata naga (*Hylocereus poyrhizus*) ialah buah bukan klimakterik dan biasanya dituai pada peringkat kemasakan penuh (indeks lima) untuk memperolehi kualiti pasaran yang terbaik. Penuaian pada peringkat ini memendekkan jangkahayat buah dan ianya mudah diserang penyakit. Kajian ini dijalankan untuk menguji kesan baik rawatan kalsium (Ca) terhadap kualiti buah dan, kesannya terhadap jangkitan antraknos yang disebabkan oleh *Colletotrichum gloeosporioides* dan reput perang yang disebabkan oleh *Monilinia fructicola*. Terlebih dahulu, ujian kepatogenan bagi empat jenis kulat yang telah diidentifikasi iaitu *C. gloeosporioides*, *M. fructicola*, *Fusarium* sp. dan *Curvularia* sp. terhadap buah mata naga telah dijalankan. Buah pada indeks kematangan penuh (indeks lima) dilukakan dan diinokulasi dengan spora kulat-kulat terbabit pada

kepekatan 10^8 spora·mL^{-1}. Selepas dua hari diinokulasi, buah yang diinokulasi menunjukkan 100% jangkitan kecuali pada buah yang diinokulasi dengan *Curvularia* sp. dan buah kawalan. Kajian diteruskan dengan mengkaji kesan kepekatan spora yang berbeza terhadap terhadap kadar jangkitan dan kesannya kepada kualiti buah. Dua kepekatan spora iaitu pada kepekatan 10^4 dan 10^6 spora·mL^{-1} telah disediakan dari kulat *C. gloeosporioides* and *M. fructicola*. Selepas tiga hari diinkubasi, kesemua buah yang diinokulasi spora menunjukkan 100% jangkitan kecuali pada buah yang diinokulasi spora *M. fructicola* pada kepekatan 10^4 spora·mL^{-1} dan juga buah kawalan. Keputusan menunjukkan tahap keterukan jangkitan bergantung kepada kepekatan spora di dalam inokulum. Pada kepekatan spora yang tinggi, penyakit reput perang yang disebabkan oleh *M. fructicola* menunjukkan tahap keterukan yang lebih tinggi berbanding dengan antraknos (disebabkan oleh *C. gloeosporioides*), dengan saiz lesion pada tiga hari selepas diinkubasi (DAI) ialah masing-masing 8.4 cm^2 dan 5.8 cm^2. Buah yang dijangkiti menjadi lembik, rendah kandungan pepejal terlarut (SSC) dan asid tertitrat (TA), akan tetapi mempunyai pH yang tinggi. Pemanjangan tempoh inkubasi daripada tiga hari kepada lima hari telah meningkatkan lagi tahap keterukan jangkitan dan merendahkan kualiti buah. Tahap keterukan penyakit pada buah yang diinokulasi *C. gloeosporioides* meningkat daripada 9.6 cm^2 pada tiga DAI kepada 63.0 cm^2 pada lima DAI. Iaitu peningkatan sebanyak tujuh kali ganda. Manakala pada buah yang diinokulasi *M. fructicola* keterukan penyakit meningkat daripada 10.1 cm^2 pada tiga DAI kepada 91.7 cm^2 pada lima DAI. Keputusan ini membuktikan ancaman penyakit antraknos dan reput perang kepada industri buah mata naga. Seterusnya, kajian dijalankan untuk mengtahui kesan rawatan pratuai kalsium klorida ($CaCl_2$) terhadap

kejadian penyakit dan kualiti buah dijalankan dengan melakukan semburan Ca secara terus kepada buah pada empat kepekatan berbeza (0, 1.0, 2.0, 3.0 and 4.0 $g \cdot L^{-1}$). Semburan dijalan setiap minggu selama sebulan. Keputusan yang diperolehi menunjukkan keterukan antraknos dan reput perang berkurangan dengan peningkatan kepekatan Ca di dalam larutan semburan. Saiz lesion pada buah yang diinokulasi dengan *C. gloeosporioides* dan *M. fructicola* masing-masing berkurangan sehingga 85 % dan 95 % apabila kepekatan Ca bertambah. Keterukan penyakit didapati berkadar songsang kepada kandungan Ca di dalam kulit buah (r = - 0.91). Semburan Ca juga berjaya meningkatkan kekerasan buah. Semburan Ca pada kepekatan 4 $g \cdot L^{-1}$ telah mengekalkan kekerasan pada buah yang dijangkiti setara dengan buah yang tiada jangkitan (menerima rawatan Ca pada kepekatan yang sama). Namun begitu, semburan Ca tidak memberikan sebarang kesan terhadap pH, SSC dan TA pada buah yang tidak dijangkiti antraknos mahupun reput perang. Sebaliknya, semburan Ca pada kepekatan yang tinggi mengekalkan nilai pH, SSC dan TA pada buah yang dijangkiti setara dengan buah yang tiada jangkitan. Keputusan yang sama diperolehi apabila buah diberikan rawatan Ca melalui rendaman di dalam larutan pada kepekatan Ca yang berbeza iaitu; 0, 1.0, 2.0, 3.0 dan 4.0 $g \cdot L^{-1}$. Rawatan Ca dijalankan pada peringkat pascatuai. Keterukan penyakit pada buah yang diinokulasi dengan *C. gloeosporioides* dan *M. fructicola* masing-masing berkurangan sehingga 70 % dan 65 % dengan pertambahan kepekatan Ca di dalam larutan. Kekerasan buah yang dijangkiti mahupun yang tiada jangkitan juga didapati meningkat dengan pertambahan kepekatan Ca. Rendaman Ca telah menurangkan kesan penyakit ke atas kualiti buah. Manakala pada buah yang tiada jangkitan, rendaman Ca tidak memberikan sebarang kesan terhadap kualiti buah. Rawatan Ca pada peringkat

pratuai mahupun pascatuai juga berjaya meningkatkan kandungan Ca di dalam buah tanpa mempengaruhi pengambilan nitrogen (N), fosforus (P), kalium (K) dan magnesium (Mg). Sebagai kesimpulan, rawatan Ca sama ada semburan pada peringkat pratuai mahupun rendam pada peringkat pascatuai telah berjaya mengurangkan tahap keterukan penyakit dan kesan penyakit terhadap kualiti buah serta meningkatkan kandungan Ca di dalam buah. Penemuan ini memberikan harapan yang baik kepada penggunaan $CaCl_2$ untuk memanjangkan jangkahayat buah. Penggunaan $CaCl_2$ juga berpotensi diaplikasikan sebagai sebahagian daripada strategi pengurusan untuk mengawal jangkitan antraknos dan reput perang pada buah mata naga.

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I certify that a Thesis Examination Committee has met on 4 November 2010 to conduct the final examination of Muhd Azlan bin Abd Ghani on his thesis entitled "Calcium Treatment Against Anthracnose and Brown Rot in Red Dragon Fruit [*Hylocereus polyrhizus* (F.A.C. Weber) Britton & Rose]" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

Members of the Thesis Examination Committee were as follows:

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that is has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

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MUHD AZLAN BIN ABD GHANI

Date: 4 November 2010

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